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C3R

(54) Flexible polyurethane foam for sound insulation purposes, process for the production and use thereof

(57) A flexible polyurethane foam for sound insulation purposes has viscoelastic properties in the temperature range of -20 to $+80$°C and a loss factor of at least 0.3, in the case of a density of less than 90 kg/m^3 and a modulus of elasticity of less than $10^6 N/m^2$. The foam is obtained by reacting a polyisocyanate with a polyol, in which at least one component has an OH-number of 180 to 400. The foam is particularly suitable for airborne sound absorption and insulation, as well as for structure-borne sound insulation.

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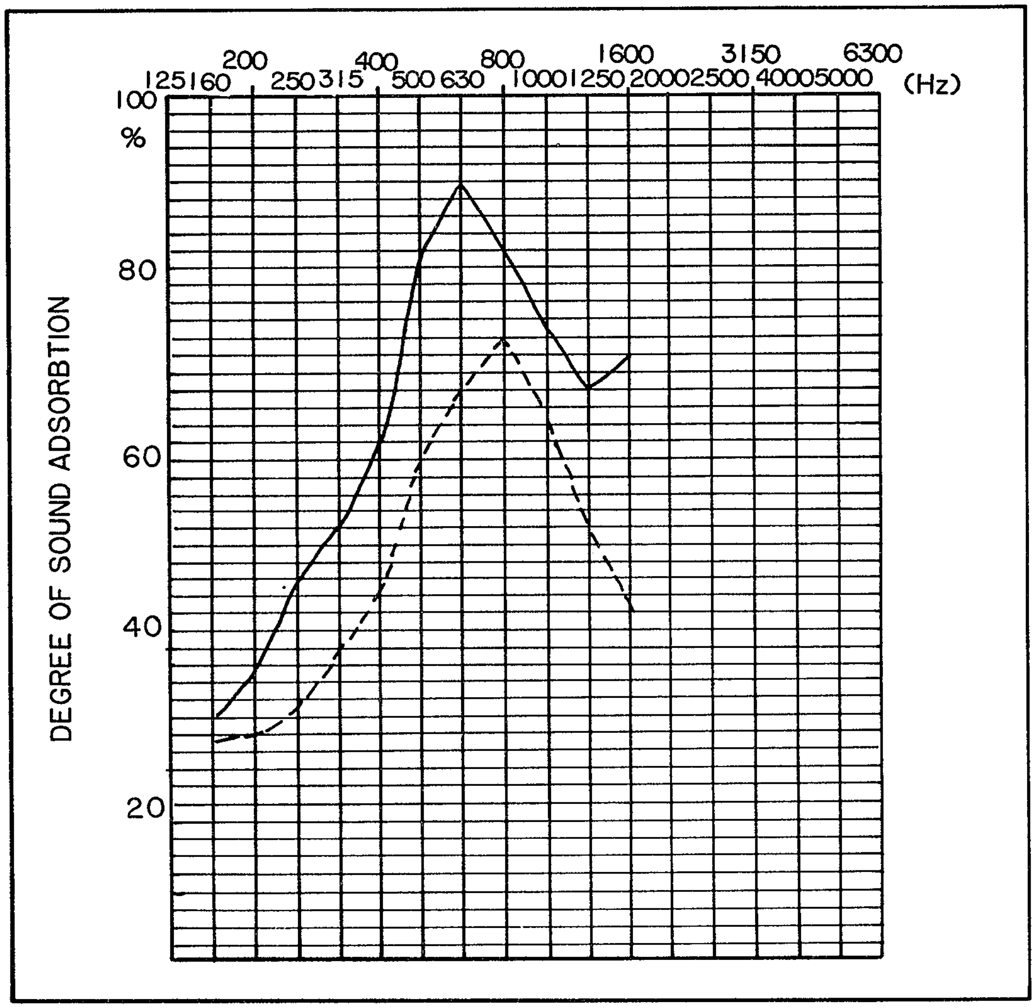
GRAPH I

DEGREE OF SOUND ABSORPTION



AVERAGE ABSORPTION COEFFICIENT (160 – 1000 Hz) ——60,
– – 52

—— VISCOELASTIC FOAM
– – – CONVENTIONAL FOAM

FIG. 1

GRAPH 2
FREQUENCY DEPENDENDENCE OF THE AIRBORNE SOUND INSULATING ACTION (MASS-SPRING SYSTEM)

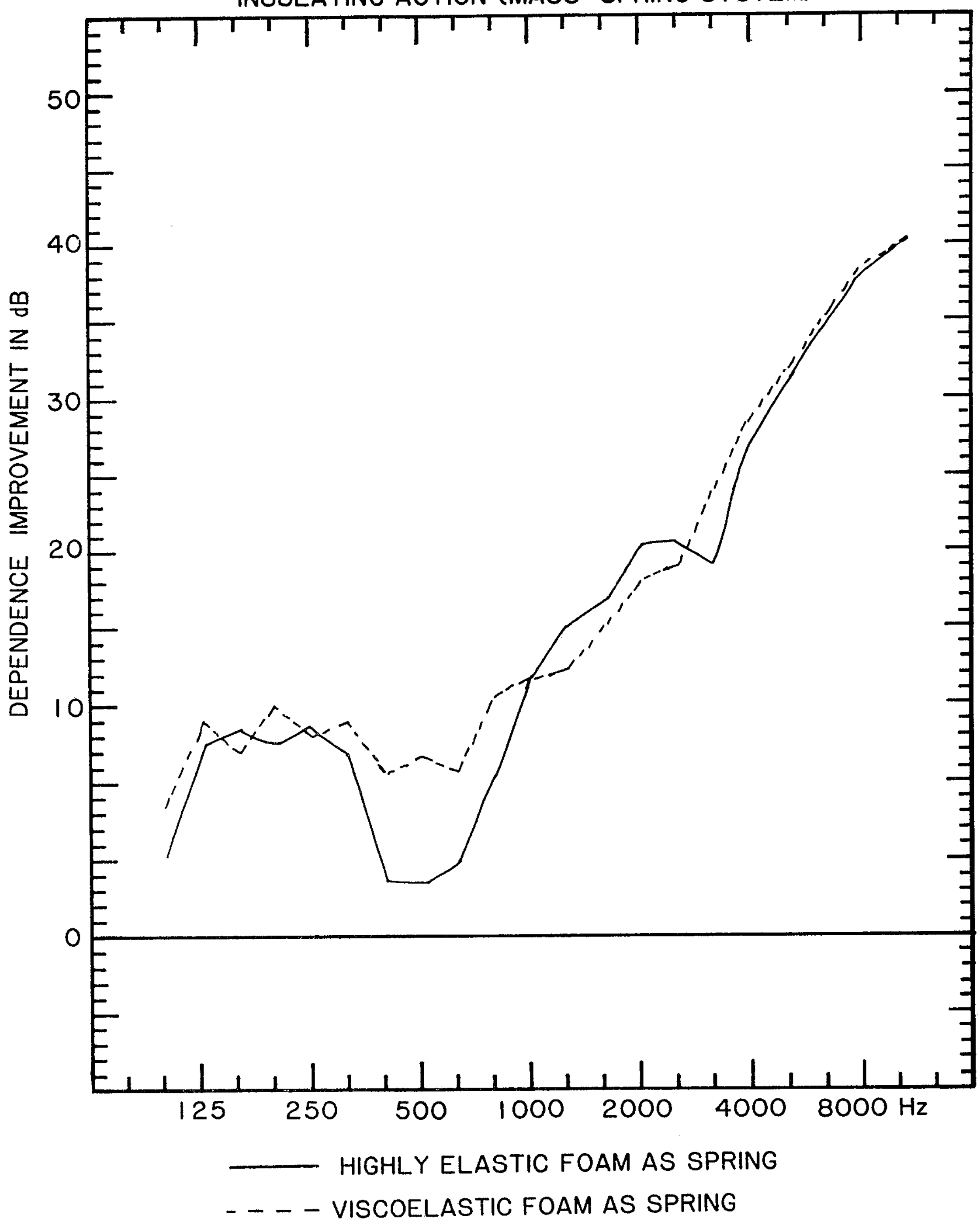


FIG. 2

SPECIFICATION

Flexible polyurethane foam for sound insulation purposes, process for the production and use thereof

Polyurethane foams have already been used in many forms for sound insulation purposes. Thus, for a long time now, mats have been used for lining the walls of motor vehicle bodies and which for obtaining a good sound insulation are made from highly filled polyurethane foam having a bulk density of 0.5 to 1.25 kg/1, cf DE–AS 1,923,161 and DE–OS 2,835,329. However, such materials have a relatively high modulus of elasticity or a low loss factor and are consequently too rigid to form the spring of a mass–spring system. In addition, in the car industry, the trend is increasingly towards lighter weight materials for sound insulation systems in order to achieve a weight saving. This demand cannot be met by the high bulk density of the materials containing more than 60% by weight of heavy fillers.

It is also known to use open-cell polyurethane foams for airborne sound absorption purposes. However, as such foams easily absorb dirt and moistures in the same way as a sponge, it is generally necessary to apply a covering layer to the absorber foam, which clearly impairs the acoustic properties.

Finally, it is known to improve sound insulation by the double-wall effect. For this purpose, a flexible plastic layer (mass) is placed on the wall to be insulated (e.g. the vehicle body) at a distance of approximately 10 to 30mm. The space between the body and the plastic layer is filled with a soft polyurethane foam (spring). Such mass–spring systems advantageously lead to better sound inslulation at higher frequencies, but suffer from the disadvantage of resonance (intrusions) at lower frequencies.

A considerable improvement in the sound insulation could be obtained by e.g. impregnating an open-pore polyurethane foam with a viscoelastic material, it also being possible to vary the nature and/or quantity of the impregnation as a function of the particular acoustic requirements, of German Patent 2,756,622. However, the manufacture of such materials is relatively costly.

The present invention provides a flexible polyurethane foam, which can easily be processed to moulded articles, optionally also as back-foaming, in conjunction with other materials and which leads to both an improvement in the airborne sound absorption and, when used as the spring in the mass–spring systems, leads to an improvement to the airborne sound insulation in the resonant frequency range. In addition, when used with or without a septum, the foam material also leads to an improvement of the structure-borne sound insulation.

According to the invention, it has been found that this can be achieved by producing a flexible polyurethane foam, which has viscoelastic properties in the practically important temperature range of -20 to $+80$°C.

Thus, the invention provides a flexible polyurethane foam for sound insulation purposes, which is largely filler-free and has a density of less than 90 kg/m^3 and a modulus of elasticity of less than 10^6 N/m^2, has a loss factor of at least 0.3 and has viscoelastic properties at temperatures of from -20 to $+80$°C.

Although the viscoelastyic foam of the invention will not normally contain any filler small amounts of filler can be tolerated. Thus, the foam according to the invention possesses a very low bulk density and a very low modulus of elasticity, the latter preferably being about 5×10^5 N/m^2. The acoustic loss factor is at least 0.3 and is preferably about 0.5. In addition, the material has good thermal stability, the permanent deformation being less than 5%, following 70% deformation at 80°C for 22 hours.

When manufacturing and processing the flexible polyurethane foam according to the invention, a polyisocyanate is reacted with a polyol mixture, in which at least one component has a OH-number of from 180 to 400, then by means of the RIM-process shaped foam articles, optionally in conjunction with other materials, are produced from the viscoelastic polyurethane. The RIM process (Reaction Injection Moulding) involves rapid injection of metered liquid streams of polyol and an isocyanate into a mold. There may also be other materials e.g. a heavy plastic film or a carpet material present in the mold when the foam is formed. The necessary demoulding times are less than 3 minutes, so that it is economically possible to manufacture large quantities.

Propylene oxide-based polyether triols are particularly suitable as polyols. However as the polyol component with a OH-number of from 180 to 400, it is also possible to use linear and branched polyester and polyols, linear and branched products of ring-opening polymerizations of tetrahydrofuran and polyethylene glycols. Preferably, the OH-number of the polyol does not exceed 350, i.e. is between 180 and 350. The proportion of the polyol component with a OH-number of 180 to 400 and preferably 180 to 350 in the polyol mixture (first component) is at least 15, but preferably 25 to 50% by weight.

The polyisocyanates can be formed by both aliphatic and aromatic isocyanates. Preference is mainly given to crude dimethyl methane diisocyanate, isomers of tolylene diisocyanates,

optionally mixtures of the two, together with DMI-prepolymers having a low molecular weight (NCO-content between 20 and 28% by weight).

The manufacture of the flexible polyurethane foam according to the invention with the aforementioned properties follows standard prior art methods for cold moulding foams (cf e.g. George Woods "Flexible Polyurethane Foams", Chemistry and Technology, 1982, particularly pp.47 to 71 and 158 to 180). For this purpose, the polyol mixture, including the standard additives such as blowing agent, cell stabilizers, catalysts, pigments, etc (first component) is reacted with the polyisocyanate (second component). It must be ensured that the NCO-characteristic or index does not exceed the value 105.

As a result of the aforementioned properties, the flexible polyurethane foams are particularly suitable for use in sound insulation. The material according to the invention can be advantageously used for airborne sound absorption, because it has a sufficiently open-cell nature. Cell opening takes place at the time of production, so that there is no need to rework the foam. When using the foam according to the invention, the airborne sound insulation with the aid of mats–spring systems is also clearly improved in the low frequency range (resonant frequencies). As a result of its viscoelastic properties, when the material is applied to structure-borne sound-emitting oscillating sheets, the material contributes to the damping thereof, when used with or without a septum.

The improvements resulting from the invention are made particularly clear on the attached graphs, which show measuring curves for conventional foams compared with those according to the invention (composition as in example 2).

Graph 1 shows a comparison between a conventional foam (Terosorb 4750 K) and the viscoelastic foam according to the invention, with respect to the degree of sound absorption, a definite improvement being obtained in the frequency range 100 to 2000 Hz, which is important for cars.

Graph 2 compares the curves for two mass–spring systems, the springs being formed in one case by a conventional highly elastic foam and the other by a viscoelastic foam according to the invention (composition as in example 1). It is clear that the foam material according to the invention largely prevents any intrusion in the range of approximately 300 to 700 Hz, such as also occurs in the prior art system.

The curves of graphs 1 and 2 were obtained on materials having the following characteristics:

Graph 1

	Conventional	Viscoelastic
	Foam	
Coating thickness	50mm	50mm
Density	45 kg/m^3	45 kg/m^3
Modulus of elasticity	10^6N/m^2	3.10^5N/m^2
Loss factor	0.08	0.32
Surface	thin skin 30 g/m^2	Closed skin

Graph 2

	Conventional	Viscoelastic
	Foam	
Coating thickness	20 mm	20mm
Density	45 kg/m^3	45 kg/m^2
Modulus of elasticity	10^6N/m^2	3.10^5N/m^2
Loss factor	0.08	0.32

Measurements took place according to DIN 52215–63 and Apamat (graph 2).

The following examples serve to further illustrate the invention. All parts and percentages are by weight unless otherwise specified.

Example 1

Production of a flexible polyurethane foam moulded article.

The following components were used for the polyurethane:

Triol based on propylene oxide/ethylene oxide, molecular weight 6500	46.1
Triol based on propylene oxide/ethylene oxide, molecular weight 4000	15.0
Triol based on propylene oxide, molecular weight 700	26.5
Water	2.0
Cell stabilizer (polyether polysiloxanes)	1.0
Catalyst (amine catalysts)	1.5
Trichlorofluoromethane	7.2
Pigment	0.7
Crude-MDI (31% NCO)	Index 100

The components were supplied to the mixing head of an RIM installation and foamed in a mould to give an open-cell moulded article. Mould removal took place after 3 minutes. The moulded article obtained was particularly suitable for the lining of motor vehicle floor mats.

Example 2
Production of a floor mat for motor vehicles with back-foaming as a flexible polyurethane foam.

The mat, which was specially finished to obtain an adequate foam density, was placed in the foaming mould, optionally together with sound insulating foils. Following application of a conventional mould parting agent and with the mould cover closed, as in example 1 the reactive mixture was poured into the mould in a just adequate quantity and mould removal was possible 2.5 to 3 minutes later.

The following slightly modified composition compared with example 1 was used for the foam.

Triol based on propylene/ethylene oxide, molecular weight 6500	41.1.
Triol based on propylene oxide/ethylene oxide, molecular weight 4000.	16.0
Triol based on propylene oxide, molecular weight 700	30.5
Water	2.0
Cell stabilizer (polyether polysiloxane)	1.0
Catalyst (amine catalysts)	1.5
Trichlorofluoromethane	7.2
Pigment	0.7
MDI-prepolymer (25% NCO)	Index 100

CLAIMS

1. A flexible polyurethane largely filler free, foam having a density of less than 90 kg/m^3, a modulus of elasticity of less than $10^6 N/m^2$ and a loss factor of at least 0.3, and possessing viscoelastic properties at temperatures of from -20 to $+80C$.

2. A polyurethane foam according to claim 1 wherein the modulus of elasticity is about $5 \times 10^5\ N/m^2$.

3. A polyurethane foam according to claim 1 or 2 wherein the loss factor is about 0.5.

4. A polyurethane foam substantially as hereinbefore described in Example 1 or 2.

5. Process for producing and processing the flexible polyurethane foam according to any one of claims 1 to 4 which comprises reacting a polyisocyanate with a polycol, in which at least one component has an OH-number of 180 to 400 said component being at least 15% by weight of the polyol and producing from the viscoelastic polyurethane by means of the RIM-process flexible foam moulded articles, optionally in conjunction with other materials.

6. Process according to claim 5 wherein demoulding times are less than 3 minutes.

7. Process according to claim 5 or 6 substantially as hereinbefore described in Example 1 or 2.

8. Use of a flexible polyurethane foam according to any of claims 1 to 4 for sound insulation purposes.

9. Use of a polyurethane foam according to any of claims 1 to 4 for airborne sound absorption and insulation.

10. Use of a polyurethane foam according to any of claims 1 to 4 for structure-borne sound insulation.

11. Use according to claim 8, 9 or 10 wherein the flexible polyurethane foam is used as

dashboard or floor mat under foaming in motor vehicles.

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